With regard to the second point, the statement in the text of the book which I questioned is as follows :—"The main principle is to employ thin layers of well-packed and pressed moss in trays with perforated bottoms, *the eggs being separated from the moss by muslin, mosquito-netting, swans' down, calico, or butter-cloth*, and that each tray contains two or three layers." In all the methods of packing salmonoid eggs in which moss is employed, the descriptions I have read state that the eggs are placed in direct contact with the moss, and Mr. Day does not justify the statement above quoted by referring to another statement in his notes, that for shorter journeys eggs are thrown off the frames on to swans' down. I doubted, and still doubt, if there is any method practised in which layers of moss are used, and are separated from the eggs by muslin or similar material.

With regard to the third point, it is true that on p. 249 of his book, in the chapter on *S. fontinalis*, Mr. Day refers to Brown Goode's "Game Fishes of the United States," and to the statement in that work that *S. namaycush* has, as its nearest relative, *S. fontinalis*. But I think a more direct reference to a speciegraphical description of *S. namaycush* might have been expected in a footnote referring to errors in the descriptions of this fish by certain writers. My remark about the omission of such reference was not made under the impression that S. *namaycush* was not a char, for I am aware that it is described as such in recent American reports on pisciculture, and have no doubt that such description is correct. But reference to speciegraphical determinations are rare in such reports, and I think readers of Mr. Day's book would have been glad of the references which he now supplies in his letter. YOUR REVIEWER.

MODERN VIEWS OF ELECTRICITY.[1]

PART III. (*continued*).

VI.

LET us now pass in review the various facts and experiences which have led us to a dual view of electricity; a kind of two-fluid theory, but in a very modified form.

First, there are the old experiments which vaguely suggest the separate existence of negative electricity, such as :—

(1) The wind from a point whether positive or negative; so that a candle gets blown always away from it, whether the point be on the prime conductor and the candle held in hand, or whether the point be held in the hand and presented to the candle or prime conductor; so, also, that a point whirligig turns the same way, whether supported on the prime conductor, or whether attached to the earth and placed near it.

(2) Phenomena connected with the spark discharge, such as Wheatstone's old experiment on what he called the velocity of electricity, with the three pair of knobs; and the double burr produced in cardboard when pierced with a spark, suggesting that something has pierced it both ways at once.

Then there are the more recently observed facts; as, for instance :—

(3) The fact that an electrostatic strain scarcely affects the volume of a dielectric; thereby at once suggesting something of the nature of a shearing or distorting stress, which alters shape but not size; a displacement of positive outwards and simultaneous negative inwards.

(4) The facts of electrolysis, and the double procession of atoms past each other in opposite directions.

(5) The phenomena of self-induction, and the behaviour of a thick wire to an alternating current. The delay also in magnetizing iron, and especially the possibility of permanent magnetism; combined with

(6) The absence of momentum in an electric current, or moment of momentum in an electro-magnet, as tested by all mechanical means yet tried.

I admit at once that many of these are mere superficial suggestions which may hardly bear examination and criticism. Only (3), (4), (5), and (6) can be at all seriously appealed to; but (5) and (6), in conjunction, seem to me to afford a sort of provisional and hypothetical proof, which (3) greatly strengthens.

At this point we must for the present again leave the question.

Representation of a Magnetic Field.

The disturbance called magnetism, which we have shown to be something of the nature of a spin—a rotation about an axis—is conspicuously not limited to the steel or iron of the magnet: it spreads out through all adjacent space, and constitutes what is called the magnetic field. A map of the field is afforded by the use of iron filings. which cling end to end and point out the direction of the force at every point.

These lines of force so mapped are to be regarded as the axes of molecular whirls. They are continuous with similar lines in the substance of the steel, and every line really forms a closed curve, of which a portion is in the steel and a portion in the air. In a wire helix, such as Figs. 16 or 29, the lines are wholly in the air, but in one part of their course they thread the helix, and in another part they spread out more or less between its faces.

But according to Ampère's theory of molecular currents there is no *essential* difference between such a helix and a steel magnet; directly the currents in the molecules of the magnet are considered, everything resolves itself into chains of molecular currents, threading themselves along a common closed curve or axis. Each atom, whether in the steel or in the air, is the seat of a whirl of electricity, more or less faced round so as on the average to have its plane at right angles to the lines of force. The simplest plan of avoiding having to consider those only partially faced round, is to imagine the whole number divided into a set which face accurately in the right direction, and a set which look any way at perfect random, and to neglect this latter set.

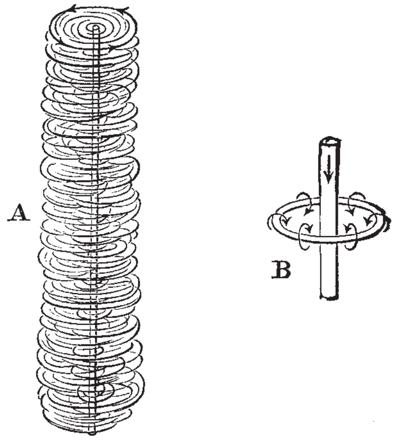

FIG. 30.—A, an element of a magnetic line of force with the electric whirl round it; B, a bit of an electric circuit with one of its magnetic lines of force shown round it, and the electric whirl round this; each magnetic line of force round a current being an electric vortex ring.

Well now try and picture a chain of whirls like beads spinning on a wire threading them all, and think of the effect of a material fluid thus rotating. Obviously it would tend to whirl itself fatter, and to shorten its length. An assemblage of such parallel straight whirls would thus squeeze each other laterally, or cause a lateral pressure, and would tend to drag their free ends together, causing a longitudinal tension.

Such whirls cannot in truth have free ends except at the boundary of a medium—as at the free surface of a liquid. Magnetic whirls are in reality all closed curves;

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[1] Continued from p. 110.

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but inasmuch as part of them may be in a mobile fluid like air, and part of them in a solid like iron or steel, it is convenient to distinguish between their two portions; and one may think of the air whirls alone as reaching from one piece of iron to another and by their shortening tendency or centrifugal force pulling the two pieces together.

The arrangement shown in Fig. 31 illustrates the kind of force exerted by a spinning elastic framework along and perpendicular to its axis of rotation.

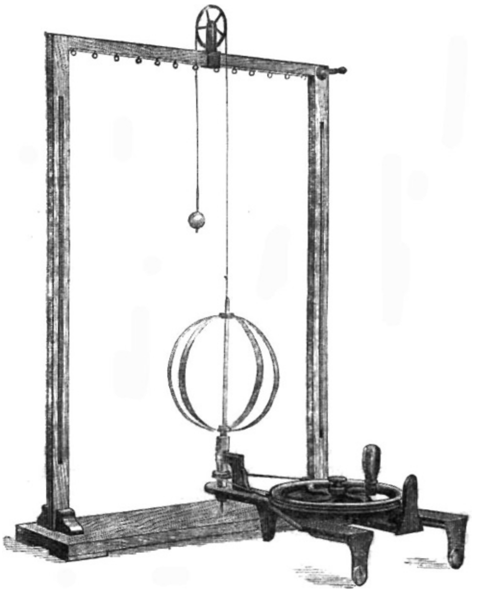


Fig. 31.—A "shape of the earth" model which, when whirled, exerts a tension along its axis, pulling up the weight attached to it, and a pressure at right angles, by reason of its bulging out.

One can easily see this effect of a whirl in a tea-cup or inverted bell-jar full of liquid. Stir it vigorously, and leave it. It presses against the walls harder than before, so that if they were elastic they would bulge out with the lateral pressure; and it sucks down the top or free end of its axis of rotation, producing quite a depression or hollow against the force of gravity. Or, as a more striking illustration, make the following apparatus.

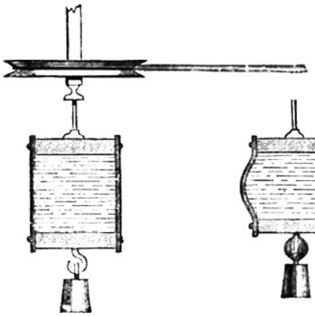
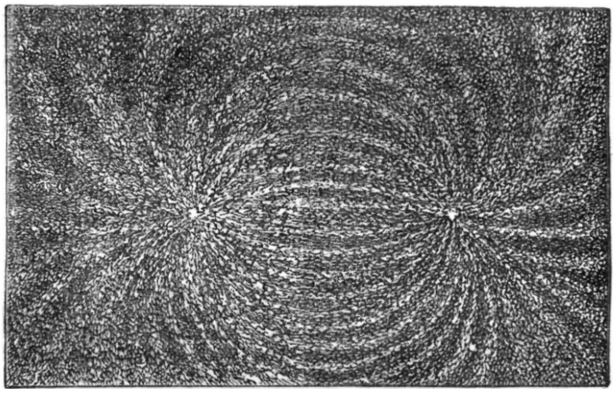


Fig. 32.—An elastic-walled cylindrical vessel full of liquid hanging from a whirling table, and, by reason of centrifugal force, raising a weight and bulging out laterally when spun, thereby illustrating a tension along the axis of rotation and a pressure in every perpendicular direction.

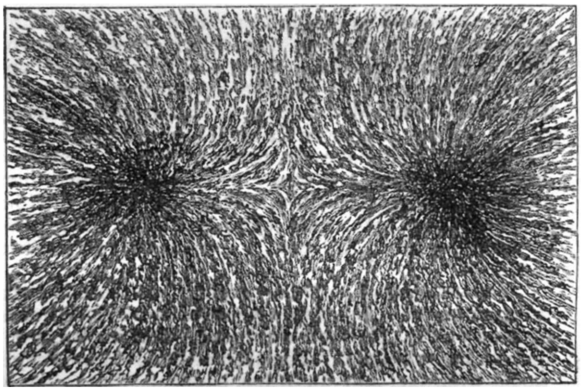
Two circular boards joined by a short wide elastic tube or drum: a weight hung to the lower board, the top board hung from a horizontal whirling table, the drum filled with water, and the whole spun round. The weight is raised by the longitudinal tension; the sides bulge out with the lateral pressure.

There is no need for the whole vessel to rotate. If the liquid inside rotates, the same effect is produced.

Imagine now a medium composed of a multitude of such cells with rotating liquid inside: let the cells be either very long, or else be joined end to end so as to make a chain—a series of chains side by side—and you have a picture of a magnetic medium traversed by a field of force. End-boundaries of the field will be dragged together, thus representing magnetic attraction; while, sideways, the lines of force (axes of whirl) squeeze each other apart, thus illustrating repulsion. This is Clerk-Maxwell's view of an electro-magnetic medium, and of the mode in which magnetic stress, and magnetic attractions and repulsions between bodies, arise.



Attraction.



Repulsion.

Fig. 33.—Attraction and repulsion. The tension along the lines of force or axes of rotation drags the one pair of poles together; and the pressure in directions perpendicular to the axis of rotation due to the centrifugal force of the whirls drives the other pair apart.

Wherever lines of force reach across from one body to another, those bodies are dragged together as if pulled by so many elastics (Fig. 33); but wherever lines of force from one body present their *sides* to those proceeding from another body, then those bodies are driven apart.

Oliver J. Lodge.

(*To be continued.*)

LANGUAGE-REASON.

The inclosed letter on "Reason-Language" was written to an American friend, and has been published in an American paper in Chicago. I thought it might possibly interest the readers of Nature.

Oxford, January 22. F. Max Müller.

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